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ABSTRACT

Attitudes toward mathematics are very important in the achievement and participation of students in mathematics. Declining national test scores in mathematics and dislike of mathematics have increased recognition of the problem of student attitudes. The purposes of this study were to develop an instrument to measure students' attitudes toward mathematics (ATMI) and to find the underlying dimensions that comprise the ATMI. The sample consisted of 544 students taking mathematics at a private bilingual preparatory school in Mexico City. Students were asked to indicate their degree of agreement with each statement, from strongly disagree to strongly agree. Variables considered were value, anxiety, motivation, confidence, enjoyment, and adults' perspectives. The alpha reliability coefficient for the whole instrument was .96. After dropping the nine weakest items, the reliability increased to .97. A principal components factor analysis with a varimax (orthogonal) rotation revealed students' sense of security, value of mathematics, motivation, and enjoyment of mathematics. The ATMI psychometric analysis revealed sound properties and can therefore be used by researchers and practitioners to measure students' attitudes toward mathematics. Contains 24 references. (Author/PVD)

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Running Head: MATHEMATICS ATTITUDES

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The Attitudes Toward Mathematics Instrument

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Paper presented at the annual meeting of the Mid-South Educational Research Association, Tuscaloosa, AL, November 1996.

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ABSTRACT

The purposes of this study were to develop an instrument to measure students' attitudes toward mathematics (ATMI) and to find the underlying dimensions that comprise the ATMI. The sample consists of 544 students taking mathematics at the American High School in Mexico City. Data were collected from intact classes representing all grade levels and levels of mathematics. The instrument consists of 49 items. Students were asked to indicate their degree of agreement with each statement using a Likert-type scale from one to five, from strongly disagree to strongly agree.

The resulting data show that the alpha reliability coefficient for the whole instrument was .96. Then, after dropping the nine weakest items, the reliability increased to .97. A principal components factor analysis with a varimax (orthogonal) rotation revealed the following four factors: (1) student's sense of security; (2) value of mathematics; (3) motivation; and (4) enjoyment of mathematics. The ATMI psychometric analysis revealed sound properties and therefore can be used by researchers and practitioners to measure students' attitudes toward mathematics.

The Attitudes Toward Mathematics Instrument

Introduction

Mathematics is used extensively in economics, education business, medicine, biology, engineering, computer science, and sociology. It is also very important in every day life. For that matter, mathematics is a very important required course in high school. Mathematics has been a problematic course for students (Dulaney, 1994) although there has been an improvement in the last few years (Dossey, 1992).

Research has been conducted in the area of gender (Leder, 1994) and ethnic (Huang, 1993) differences in the learning of mathematics. Hallowell and Duch (1991) reported a significant gain in confidence about learning and performing well in mathematics when using computer as another tool during instruction.

Educators have become more concerned with the affective outcomes of educational programs. The development of a positive attitude toward the subject being studied is probably one of today's most prevalent educational goals. Teachers as well as parents believe that a student's attitudes toward a school subject will affect that student's achievement in the subject (Michaels & Forsyth, 1978).

The learning of mathematics has been a concern to educators and parents as well. Much have been said about the decline of mathematics scores on the Scholastic Aptitude Test. Reports have indicated that American students rank last when compared with students from all other industrialized countries on 19 assessments (Golberg and Harvey, 1983). However, mathematics is considered by the American public to be the most important academic field (Gallup, 1983).

Literature Review

Teachers are always interested in pupils' attitudes toward the subject they are teaching, but teachers of mathematics are particularly concerned about students' feelings about their subject because mathematics has a reputation for being unpopular. It is for that reason that extensive research has been conducted in the area of attitudes toward mathematics.

Researchers involved in studies of developing and influencing of attitude toward mathematics have dealt almost exclusively with enjoyment of the subject or anxiety in its presence. Different psychometric procedures have been applied in constructing the measures of attitude employed in such studies, the aspect of attitude assessed by these instruments usually involves only one of the affective goals of mathematics instruction. (McCallon & Brown, 1971; Aiken, 1972; and Aiken, 1974).

Research has indicated that attitudes toward mathematics are very important in the achievement and participation of students in mathematics. Gallagher and De Lisi (1994) indicated a positive relationship between performance on standardized mathematics and positive attitudes toward mathematics. Attitudes toward mathematics have been to be predictive of final mathematics course grade and the intention to continue to participate in mathematics courses once enrollment becomes optional (Thorndike-Christ, 1991). Research indicates a positive correlation between math experiences and attitudes (Shashaani, 1995). Attitudes toward mathematics, especially enjoyment, confidence, and perceived usefulness of mathematics , influence persistence in mathematics (Stage et al. in Klein, 1985)

Studies have indicated that math anxiety is directly correlated to previous school mathematics performance, as well as the attitudes developed during those prior mathematical experiences (Hauge, 1991). Research has indicated a positive correlation between math experiences and attitudes

(Shashaani, 1995). Positive attitudes toward mathematics were found to be inversely related to math anxiety. Research has also indicated that more negative attitudes develop as students grow (Terwilliger & Titus, 1995).

Other aspects of attitudes have been also studied regarding mathematics. Self-confidence has been found to be a good predictor of success in mathematics (Goolsby et al, 1988). In a study conducted by Randhawa (1993) self-efficacy was found to be a significant mediator between mathematics attitude and achievement. Research has also indicated that changes at the affective and achievement level have more effect on participation in mathematics hose aimed at cognitive levels (Linn and Hyde, 1989).

The home environment is a very important part of the student's learning process. Parents actively participate in the student's education. The family plays an important part in socializing the student to school. Thus, having an effect in the learning of mathematics and attitudes toward mathematics. The parents' support or lack of support of student is considered an important factor in students' participation in mathematics and attitudes toward mathematics (Kenschaft, 1991).

Educational researchers, educators, and educational organizational have always had a special interest in teachers and teacher's behavior. Teachers play a very important role in the students' learning of mathematics and attitudes toward mathematics (Dossey, 1992).

The student makes the final decision and the connections. Extensive research has been conducted on student's learning behavior. A student brings to the learning setting his or her attitudes, background, beliefs, preferences, and learning style (Chang, 1990).

Dwyer (1993) made a review of the literature on research that had been done in the development of instruments to measure attitudes. Previous studies were reviewed under the

following categories: (a) Definitions and components, (b) the measurement of attitude, (c) technique for attitude scale construction, (d) test construction statistics, and (b) mathematics related attitude scale.

Instruments studied were designed to measure achievement in mathematics, experience with mathematics, and other personality variables. Researchers concluded that attitude toward mathematics appears to be related to achievement and ability in mathematics but not to temperament or other personality variables represented by the instruments in the study. Research also shown the effect of teacher attitude toward mathematics on student attitude and achievement in mathematics. Analysis of data indicated that teacher attitude was significantly related to student attitude but not to student achievement. The study also provided evidence suggesting that the effect of teacher attitude on student attitude and achievement is cumulative. Students appeared to achieve higher in mathematics if they had a sequence of three teacher with favorable attitudes toward mathematics.

The review of the literature has provided information concerning the attitudes toward mathematic and the different aspects that affect those attitudes. The research here indicates that there exists a great body of knowledge on the different factors that influence the students' attitude toward mathematics Research has also indicated that there is a need for instruments that measure the students' attitude towards learning of mathematics.

Method

Subjects

This instrument was intended to be used with middle school and high school students in the United States and Mexico. In this study, subjects were high school students from a private bilingual preparatory school in Mexico City.

Purpose

Declining national test scores in mathematics and dislike of mathematics have increased attention to students' attitudes since these attitudes are important in the students' achievement and performance. The need for employees in the qualitative fields has also increased the importance of attitudes towards mathematics because attitudes influence persistence in mathematics. The purpose of developing this instrument was to investigate students' attitudes toward mathematics

Variables and Theoretical Construct

The theoretical construct under consideration for developing this instrument was the attitudes toward mathematics. Value, anxiety, motivation, confidence, enjoyment, and adults' perspectives have an impact on the attitudes toward mathematics. Thus the variables in consideration are value, anxiety, motivation, confidence, enjoyment, and adults' perspectives.

Instrument

The instrument developed has two sections. A demographic section and an attitude inventory section. Directions were provided at the beginning of each section in such a way that no special skill is necessary to either take or give this instrument.

In the demographic part eight questions were asked. The purpose of these questions was for identifying the student, gender, grade level, date, level of mathematics, current grade in mathematics, program of study, and nationality. This part was designed to be used with a Mexican population. For using this instrument in the United States this section has to be adjusted. The question of the program of student will be deleted and nationality will be changed to ethnic background. The attitude inventory part had forty-nine items. The construction of these items was based on the six variables, value, anxiety, motivation,, confidence, enjoyment, and adults' perspectives. The items were

constructed using a Likert scale for the response. There were five possible alternatives for the response from strongly disagree, disagree, neutral, agree, to strongly agree.

In order to score the results each response was given a value. A value of one was given to a strongly disagree response, two was given to a disagree response, three was given to an answer of neutral, four to an agree answer, and five was given to strongly agree. Twelve items of this instrument were reversed items. Those items were given the appropriate value when finding the total test score. This instrument attempted to measure attitude toward mathematics in relation to the six aspects stated in the research purpose. Table 1 gives sample items on this instrument.

Table 1

Excerpt from the *Mathematics Attitude Inventory*

Directions: This inventory consists of statements about your attitude towards mathematics. There are no correct or incorrect responses. Please think briefly about how you regard each statement.

PLEASE USE THESE RESPONSE CODES:

1 - STRONGLY DISAGREE
2 - DISAGREE
3 - NEUTRAL/NO OPINION
4 - AGREE
5 - STRONGLY AGREE

1 Mathematics makes me feel uncomfortable.

2. I have a lot of self-confidence when it comes to mathematics.

3. Mathematics is a very worthwhile and necessary subject.

4 I think studying advanced mathematics is useful.

5. I get a great deal of satisfaction out of solving a mathematics problem.

6 Mathematics is a very interesting subject.

7 The challenge of math appeals to me.

Sample Description

Five hundred and forty four high school students from a private bilingual college preparatory school in Mexico City. There were two hundred ninety one males and two hundred and fifty three females from all four grades of high school. Only students taking mathematics were in the sample. Intact classes were used in the sample. Students were in classes of all seven mathematics high school teacher.

Item Analysis

To determine internal consistency and item reliability, item-to-total correlations were examined. These correlations were computed using the SAS package. Table 2 shows the item-to-total correlations. All of the items had $\rho_{it} \geq 0.49$. Only nine items had correlations lower than 0.49. These nine items were dropped from the instrument.

Table 2

Item Analysis Data

Item	Mean	Std Dev	Item to Total Correlation
ITEM 1	4.20	0.85	.5996
ITEM 2	4.08	0.86	.5766
ITEM 3	3.44	1.08	.5596
ITEM 4	4.07	0.87	.4993
ITEM 5	3.92	0.91	.5060
ITEM 6	3.65	1.01	.5125
ITEM 7	3.70	1.03	.5763
ITEM 8	3.70	0.96	.4994
ITEM 9	3.04	1.35	.7167
ITEM 10	3.66	1.14	.7154
ITEM 11	3.63	1.10	.6281

(table continues)

Table 2, continued

Item Analysis Data

Item	Mean	Std Dev	Item to Total Correlation
ITEM 12	3.65	1.12	.7390
ITEM 14	3.46	1.21	.6864
ITEM 15	3.43	1.20	.8049
ITEM 16	3.75	1.09	.6893
ITEM 17	3.30	1.15	.6850
ITEM 18	3.10	1.10	.7270
ITEM 19	3.15	1.06	.6705
ITEM 20	3.40	1.07	.6596
ITEM 21	3.47	1.01	.6659
ITEM 22	3.52	1.03	.7076
ITEM 23	3.26	1.07	.7441
ITEM 24	3.30	1.15	.7243
ITEM 25	3.17	1.17	.7323
ITEM 26	3.38	1.12	.6614
ITEM 27	3.07	1.01	.6975
ITEM 28	3.33	1.45	.5318
ITEM 29	3.24	1.27	.6656
ITEM 30	3.05	1.16	.8158
ITEM 31	2.45	1.10	.6716
ITEM 32	3.37	1.06	.7111
ITEM 33	3.20	1.27	.6608
ITEM 34	3.12	1.24	.6982
ITEM 35	3.13	1.10	.7545
ITEM 37	3.57	1.04	.5973
ITEM 38	3.63	0.97	.5586
ITEM 41	3.24	1.04	.5444
ITEM 42	3.42	1.05	.6318
ITEM 48	3.94	1.04	.5969
ITEM 49	3.30	1.08	.7640

Item-to-total correlations were used in order to decide the items that needed to be deleted. The purpose of deleting items was to increase the value of alpha. The criteria for deleting items that was used was a value less than .3, starting with the item with the lowest item-to-total correlation.

In order to increase the value of alpha we looked at the item-to-total correlation table. From this table items with negative or lowest item-to-total correlation were selected. Those items were deleted one at a time to increase the value of alpha. This process was continued until alpha stop increasing. Nine items were deleted in order to increase the value of alpha.

Item-to-total correlations were calculated on the reduced instrument. All items had $\rho_{iT} \geq .49$.

Reliability

To determine the reliability of the instrument, Cronbach alpha was computed using the SAS package. On the original instrument coefficient α was 0.9642. Though this value is an acceptable value for reliability an item deletion process was performed in order to increase the reliability of the instrument. Items were deleted one at a time, based on their item-to-total correlation, in order to increase the value of α.

After deleting items 13, 36, 39, 40, 43, 44, 45, 46, and 47 alpha had a value of .9667. No more deletions would give us an increase in the value of alpha. The standard deviation of the revised instrument was 32.05 and the reliability was .9667. Thus giving a standard error of measurement of 5.84.

A coefficient α of 0.9667 indicates good reliability and good internal consistency for this instrument. The test items are homogeneous, tending to measure a single common trait.

Validity

Content and construct validity were of primary concern in the development of this instrument. Content validity was established in the development of the items by having a blueprint of the domains that needed to be assessed that related to the four variables that were going to be measured. Also, the items were examined by two experienced mathematics teachers. Feedback from these teachers

was used to add and modify items.

Construct validity was achieved by showing item homogeneity (Gregory, 1992). As can be seen in Table 2 all the items had an item-to-total correlation higher than .49. Hence, the instrument is unidimensional, measuring only one construct.

Another method that was used to determine construct validity was by using factor analysis. For that reason, factor analysis was conducted.

Factor Analysis

Factor analysis was performed in order to check for construct validity (Crocker & Algina, 1986). Principal component analysis with a varimax rotation was used for the factor analysis on the instrument.

Factor structures were selected based on eigenvalues and scree plot. Only factors with eigenvalues greater than one were selected. From then it was a combination of scree plot, the position of items and values for each factor on the Rotated Factor Pattern and the total amount of variance explained by those factors. The final results can be seen in Table 3.

Factor analysis was conducted with three, four, five, six, and seven factors. Both the three and four factor structures resulted in good factor loadings matrices. After examining the items in the factor loading matrices, the four-factor structure provided the best simple structure fit. The four-factor structure accounts for a total of 59.22% of variance.

Table 3

Principal Component Analysis of Attitudes Toward Mathematics Instrument: A Four-Factor Solution with a Varimax Rotation N=544

Item	Factor I *Sense of Security*	Factor II *Value*	Factor III *Motivation*	Factor IV *Enjoyment*	Communality Estimates
12	.78				.72
11	.78				.65
16	.77				.67
14	.77				.66
22	.76				.67
10	.76				.68
18	.70				.66
17	.69				.59
19	.68				.62
21	68				56
9	66				.60
23	.64				66
15	.63				.70
49	60				.64
20	.56				.50
1		.75			.67
7		.71			.60
5		.71			56
6		.65			.51
38		.60			.47
4		.60			.46
8		.59			.47
2		.54			.50
48			.49		.55
37			.51		.57
34			.72		.73
33			.72		.67
35			.56		.66
29			.55		.55
24			.52		.60
25			.49		.62
28			.47		.35
42				.62	.58
41				.60	.48

(table continues)

Table 3, continued

Principal Component Analysis of Attitudes Toward Mathematics Instrument: A Four-Factor Solution with a Varimax Rotation N=544

Item	Factor I *Sense of Security*	Factor II *Value*	Factor III *Motivation*	Factor IV *Enjoyment*	Communality Estimates
3				.54	.51
30				.53	.75
27				.50	.59
31				.49	.53
32				.47	.62
26				.42	.50
Sum of Squared Factor Loadings	9.20	5.53	5.19	3.77	23.69
% of Variance	22.99	13.82	12.97	9.44	59.22

Four factors were retained and six were the original variables. Two variables were combined and one variable was not relevant in the factor structure. Factor I related to the student's sense of security. This factor was formed by items dealing with anxiety and confidence of the original variable list. The other three factors were perfect match with value, motivation, and enjoyment, three of the variables previously described. Factor II related to value. Factor III related to motivation. Factor IV dealt with enjoyment of mathematics. The variable that was not represented in the factor analysis was adults' perspectives. Items in this category were dropped due to their low item-to-total correlation. Some of the items grouped in the different factors can be seen in Table 4.

Table 4

Items grouped by Factors

FACTOR 1 - SENSE OF SECURITY

1. Mathematics makes me feel uncomfortable.
2. I have a lot of self-confidence when it comes to mathematics

FACTOR2- VALUE

1. Mathematics is a very worthwhile and necessary subject.
2. I believe studying mathematics helps me with problem solving in other areas.

FACTOR3 - MOTIVATION

1. I am willing to take more than the required amount of mathematics.
2. The challenge of math appeals to me.

FACTOR 4 - ENJOYMENT

3. I get a great deal of satisfaction out of solving a mathematics problem.
26. I like to solve new problems in mathematics.

Having retained four factors, a reliability analysis was conducted for each factor. The fifteen items of the Sense of Security factor had a reliability of 0.95. Eight items were grouped under the Value factor. These items had a reliability of 0.86. The Motivation factor consisted of nine variables with a reliability of 0.89. The last eight items left were grouped under the Enjoyment factor. The items in this factor had a reliability of 0.88.

Conclusions

The revised Mathematics Attitude Inventory is a reliable instrument that demonstrates content and construct validity. The revised instrument consists of forty statements and the responses are on a Likert-type scale of five responses from strongly disagree to strongly agree. The instrument has a coefficient alpha of 0.97 with standard error of measurement of 5.67. Item-to-total correlations

indicate good internal consistency. Principal component analysis with a varimax rotation resulted in a four-factor structure as the best simple fit for these items. The four subscales were identified as sense of security, value, motivation, and enjoyment.

This instrument was tested only at the high school level. Even though it was a relatively large sample all subjects were from the same high school. This is a limitation of the study. Hence, the results can only be generalized to high school students of this high school in particular. The results obtained in this study are acceptable but there is room for improvement. A problem encountered was that all items from the category dealing with adults' perceptions were dropped due to low item-to-total correlations. Probably that would not had been the case if the sample had included middle school students. Hence, the instrument should be tested at the middle school.

This instrument might be useful for mathematics teachers to know not only the attitudes toward mathematics of their students but their own attitudes. So, they could provide better instruction and guidance to every student.

One aspect of this instrument that was not tested was the relationship between the demographic data and the attitude inventory part. Probably some useful information can be obtained that relates to gender, ethnic background, and mathematics achievement to the test.

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